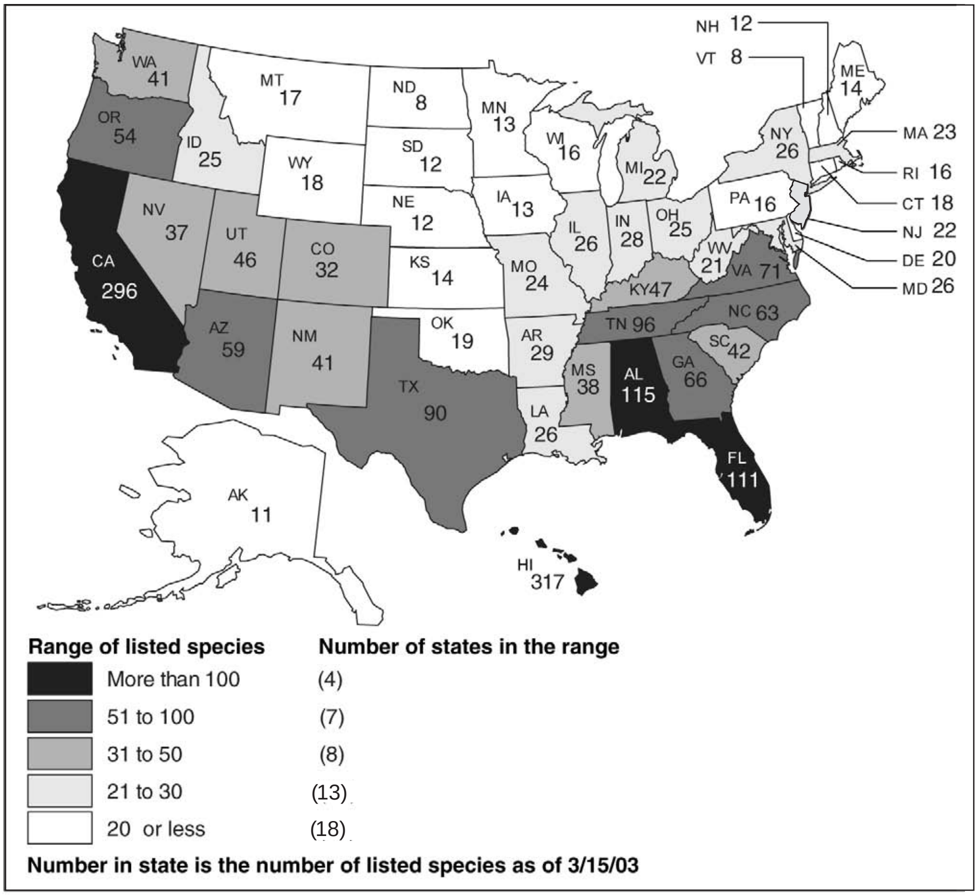
Interior's Fish and Wildlife Service and Commerce's National Marine Fisheries Service are responsible for administering the Endangered Species Act. This act requires federal agencies to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any listed species of plant or animal or adversely modify or destroy designated critical habitat.[24] The Fish and Wildlife Service is responsible for administering the act for land and freshwater species, and the National Marine Fisheries Service is responsible for marine species, including Pacific salmon, which spend part of their lifespans in freshwater. To implement the act, the agencies identify endangered or threatened species and their critical habitats, develop and implement recovery plans for those species, and consult with other federal agencies on the impact that their proposed activities may have on those species. If the Fish and Wildlife Service or National Marine Fisheries Service finds that an agency's proposed activity will jeopardize an endangered or threatened species, then a "reasonable and prudent alternative" must be identified to ensure the species is not jeopardized.[25] Numerous endangered species rely on the nation's waters, as shown in figure 10. The Endangered Species Act can affect water management activities, for example, by necessitating certain stream flow levels to avoid jeopardizing listed species or critical habitat.

[24] 16 U.S.C. §1536(a)(2).

[25] 16 U.S.C. §1536(a)(3)(a).

Figure 10: Number of Listed Threatened and Endangered Species by State, as of March 2003

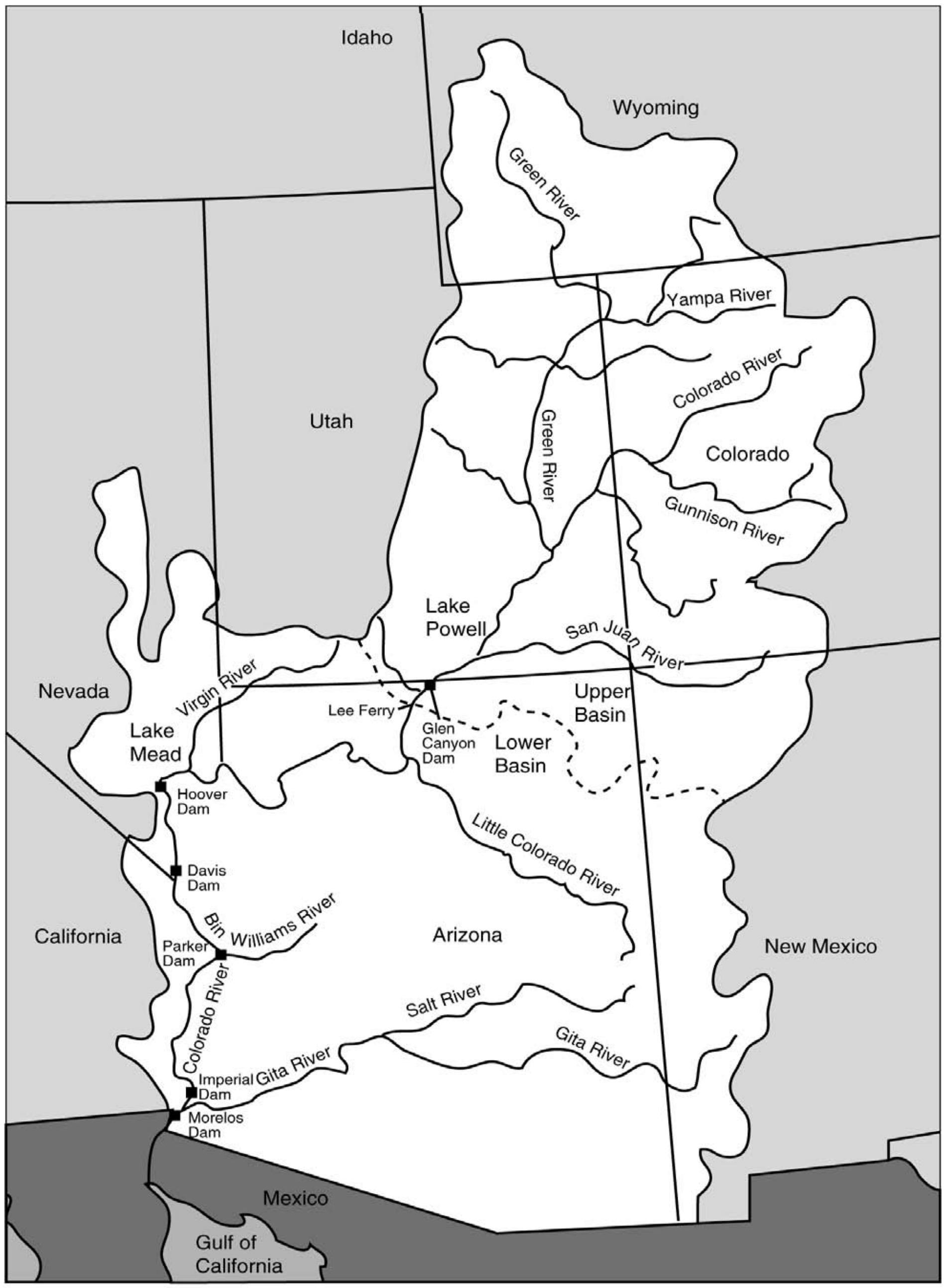


Sources: U.S. Fish and Wildlife Service (data) and GAO (analysis).

Agencies Help Develop and Implement Water-Management Agreements

States enter into agreements—interstate compacts—to address water allocation, quality, and other issues on rivers and lakes that cross state borders. According to the Fish and Wildlife Service, at least 26 interstate compacts address river water allocation between two or more states; 7 address water pollution issues; and 7 address general water resource issues, including flood control. Federal agencies may assist in developing and implementing these compacts, provide technical assistance, participate in and consult with oversight bodies, develop river operating plans, act as stewards of tribal and public natural resources, and enforce compacts. For example, the Supreme Court appointed the Secretary of Interior as the River Master responsible for implementing the water allocation formula of the 1922 Colorado River Compact. Under the compact, the states of the Upper Colorado River Basin (Colorado, New Mexico, Utah, and Wyoming), as shown in figure 11, are required to deliver to the states of the Lower Basin (Arizona, California, and Nevada) a minimum of 75 million acre-feet of water over 10-year periods.

Figure 11: Colorado River Basin Crosses Seven State Borders



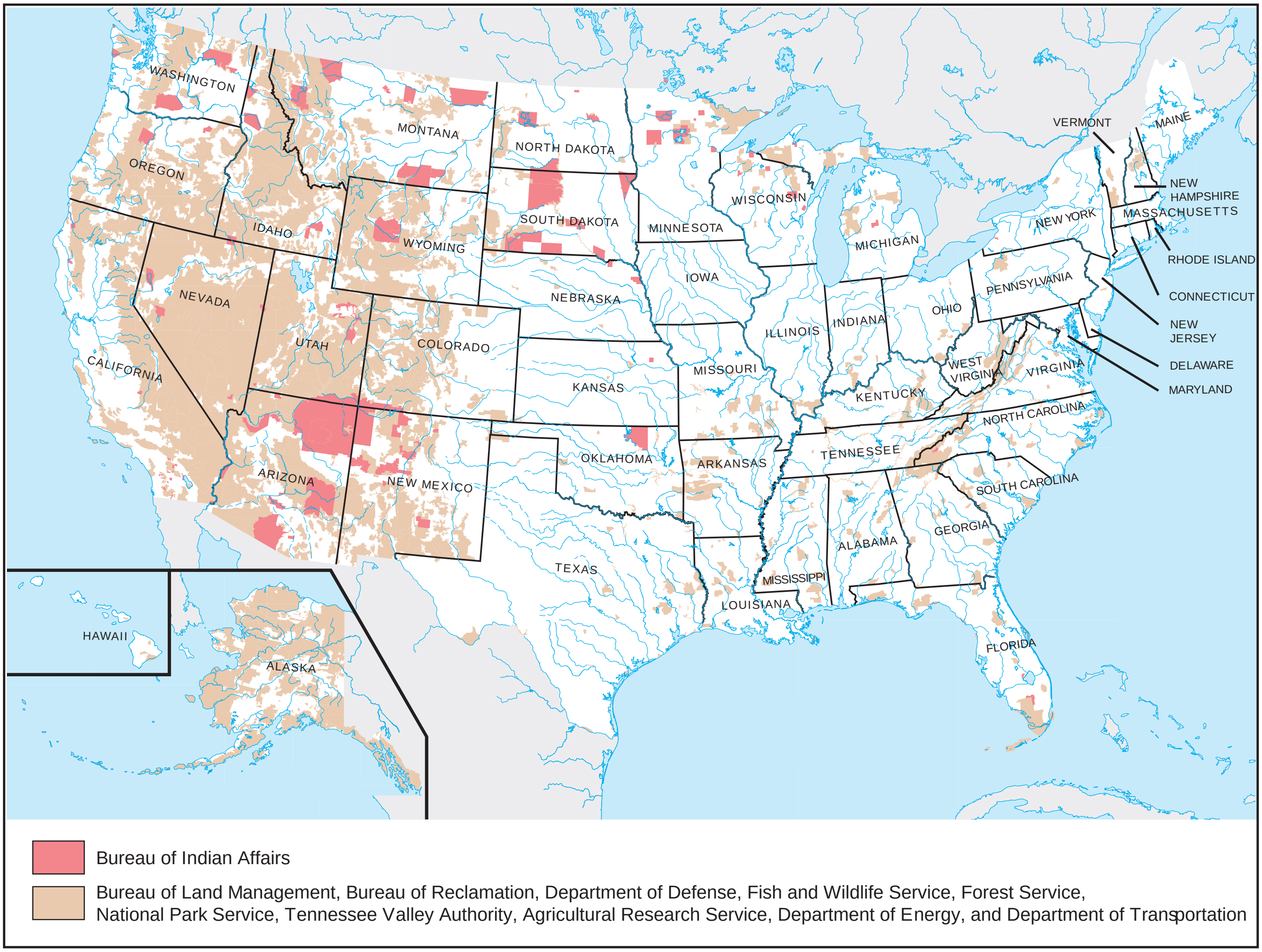
Source: Bureau of Reclamation.

Through international treaties with Canada and Mexico, the United States can coordinate activities such as water allocation, flood control, water quality, and power generation activities, as well as resolve water related disputes along the nations' international borders. The 1909 Boundary Water Treaty established the International Joint Commission of the United States and Canada, and the 1944 Water Treaty with Mexico provided the International Boundary and Water Commission with the authority to carry out the treaty. These bi-national commissions help the member nations coordinate water management activities, monitor water resources, and resolve disputes. For example, the International Boundary Water Commission recently facilitated an agreement between Mexico and the United States regarding Mexico's water debt under the treaty.

Agencies Are Responsible for Federal and Tribal Water Rights

Numerous federal natural resources management agencies and the Bureau of Indian Affairs are trustees for the water rights of federal and tribal lands. The states grant the great majority of water rights to these agencies, but the agencies also have federal reserved rights. The federal government has reserved water rights to fulfill the purposes of federal lands such as national forests, national parks, and wildlife refuges and for tribal lands. Federal lands account for 655 million acres, or 29 percent, of U.S. lands, primarily in the Western states as shown in figure 12.

Figure 12: Federal and Tribal Lands in the United States



Source: National Atlas of the United States.

The exact number and amount of federal reserved rights are not known. However, Bureau of Land Management officials estimate that 20 percent of the agency's water rights are federally reserved, largely for underground springs. The Fish and Wildlife Service estimated that it has very few federally reserved rights: almost all water rights for their activities are state granted. A Forest Service official estimated that half of the service's water rights are federally reserved. The National Park Service relies on both federal reserved and state granted rights, depending on the specific park circumstances.

The Bureau of Indian Affairs, as trustee for tribal resources in the United States, has the primary statutory responsibility for protecting tribal water rights. The Supreme Court has found that water rights in a quantity sufficient to fulfill the purposes of the reservations are implied when the United States establishes reservation lands for a tribe.[26] Tribes typically use water rights to ensure water is available for irrigation, hydropower, domestic use, stockwatering, industrial development and the maintenance of instream flows for rivers.

Objectives, Scope, and Methodology

To assist congressional deliberations on freshwater supply issues, we identified (1) the current conditions and future trends for U.S. water availability and use, (2) the likelihood of shortages and their potential consequences, and (3) state views on how federal activities could better support state water management efforts to meet future demands.

To identify the current conditions and future trends for U.S. water availability and use, we met with federal officials and collected and analyzed documentation from Reclamation, USGS, the Bureau of Indian Affairs, Bureau of Land Management, National Park Service, and Fish and Wildlife Services within the Department of the Interior; the Natural Resources Conservation Service, Forest Service, Rural Utilities Service, Agriculture Research Service, Economic Research Service, and Cooperative State Research, Education, and Extension Service within the Department of Agriculture; the National Weather Service and National Marine Fisheries Service within the Department of Commerce; the Army Corps of Engineers within the Department of Defense; the Federal Emergency Management Agency within the Department of

[26] *Winters v. United States,* 207 U.S. 564 (1908).

Homeland Security; the Environmental Protection Agency; and the Federal Energy Regulatory Commission. Although rising demands and environmental pressures have encouraged discussions of market based solutions, we assumed a continuation of current pricing and quantity allocation practices in our discussion of supply and demand trends and water shortages.

We analyzed the reports of past federal water commissions, including the U.S. Water Resources Council, National Water Commission, and the Western Water Policy Review Advisory Commission, and nonfederal organizations, such as the Western States Water Council and American Water Works Association. We also analyzed National Research Council, Congressional Research Service, and our own reports.

To determine the likelihood of shortages and their potential consequences, we analyzed water shortage impact information from the National Drought Mitigation Center at the University of Nebraska-Lincoln, the National Oceanic and Atmospheric Administration's National Climatic Data Center, and from the states. We did not assess the accuracy of the various estimates of the economic impacts of water shortages. We obtained information from Congressional Research Service reports, our own reports, and analyzed media accounts of water shortages. We obtained the views of state water managers regarding the likelihood of water shortages using a Web-based survey of managers in the 50 states.

To obtain states' views on how federal activities could better support state water management efforts to meet future demands, we conducted a Web-based survey of state water managers in the 50 states. We developed the survey questions by reviewing documents and by talking with officials from the federal agencies listed above and the state water managers in three state offices—Arizona, Illinois, and Pennsylvania. The questionnaire contained 56 questions that asked about state water management; collection and dissemination of state water quantity data by federal agencies; federal water storage and conveyance within their state; the effects of federal environmental laws on state water management; the effects of interstate compacts and international treaties on state water management; and the effects of federal and tribal rights to water on state water management.

We pretested the content and format of the questionnaire with state water managers in Georgia, Florida, Virginia, and Washington. During the pretest we asked the state managers questions to determine whether

(1) the survey questions were clear, (2) the terms used were precise, (3) the questionnaire placed an undue burden on the respondents, and (4) the questions were unbiased. We also assessed the usability of the Web-based format. We made changes to the content and format of the final questionnaire based on pretest results.

We posted the questionnaire on GAO's survey Web site. State water managers were notified of the survey with an E-mail message sent before the survey was available. When the survey was activated, an E-mail message informed the state water managers of its availability and provided a link that respondents could click on to access the survey. This E-mail message also contained a unique user name and password that allowed each respondent to log on and fill out their own questionnaire. To maximize our response rate we sent reminder E-mails, contacted non-respondents by telephone, and mailed follow-up letters to non-respondents.

Questionnaires were completed by state water officials in 47 states (California, Michigan, and New Mexico did not participate) for a response rate of 94 percent. We performed analyses to identify inconsistencies and potential errors in the data and contacted respondents via telephone and E-mail to resolve these discrepancies. We did not conduct in-depth assessments of the state water official's responses. A technical specialist reviewed all computer programs for analyses of the survey data. Aggregated responses of the survey are in appendix I.

We conducted our work from March 2002 through May 2003 in accordance with generally accepted government auditing standards.

Freshwater Availability and Use Is Difficult to Forecast, but Trends Raise Concerns about Meeting Future Needs

No federal entity has comprehensively assessed the availability and use of freshwater to meet the nation's needs in 25 years. While forecasting water use is notoriously difficult, numerous signs indicate that our freshwater supply is reaching its limits. Surface-water storage capacity is strained and ground-water is being depleted as demands for freshwater increase because of population growth and pressures to keep water instream for environmental protection purposes. The potential effects of climate change create additional uncertainty about the future availability and use of water.

National Water Availability and Use Has Not Been Assessed in Decades

National water availability and use was last comprehensively assessed in 1978.[1] The U.S. Water Resources Council, established by the Water Resources Planning Act in 1965,[2] assessed the status of the nation's water resources—both surface-water and ground-water—and reported in 1968 and 1978 on their adequacy to meet present and future water requirements. The 1978 assessment described how the nation's freshwater resources were extensively developed to satisfy a wide variety of users and how competition for water had created critical problems, such as shortages resulting from poorly distributed supplies and conflicts among users. The Council has not been funded since 1983.

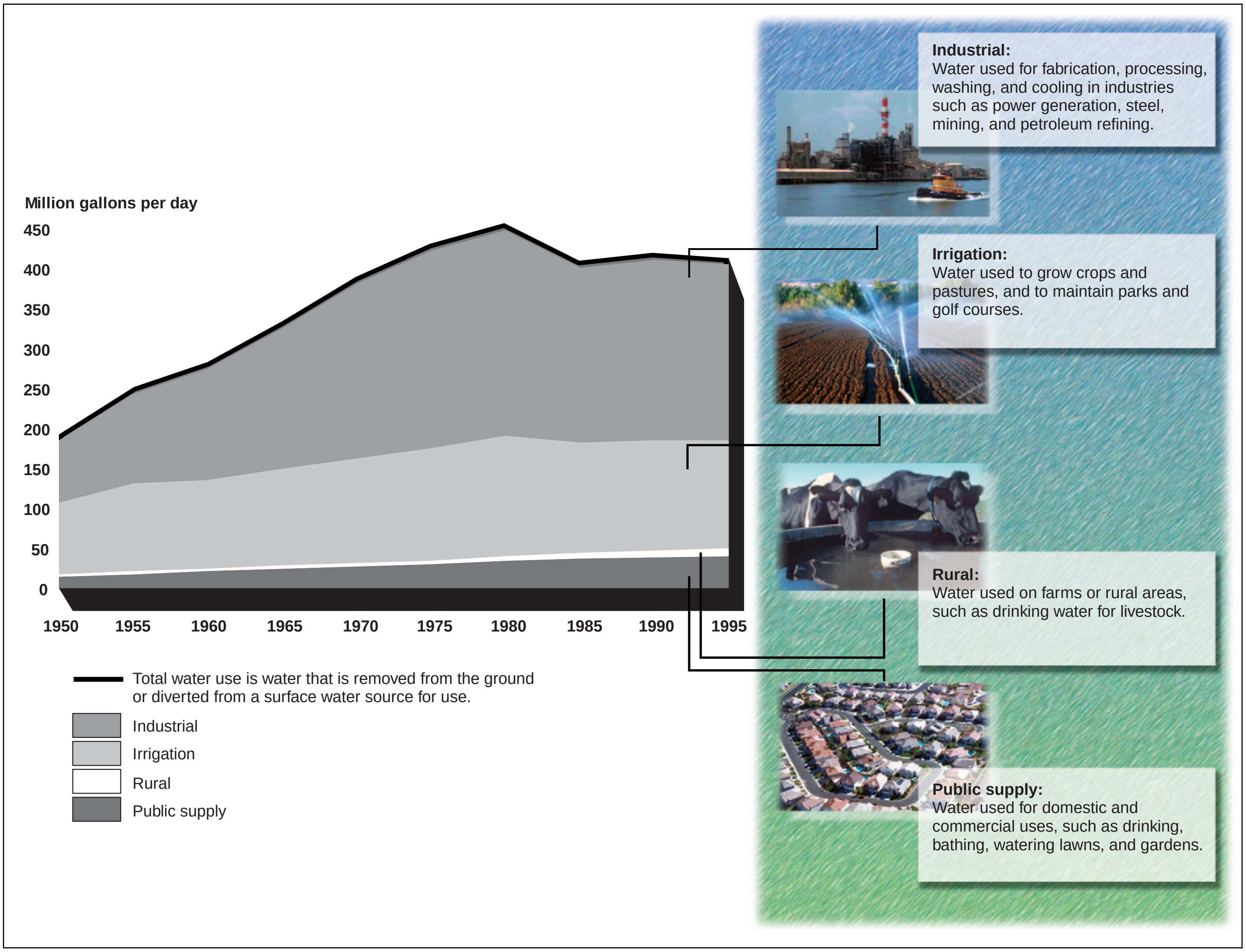
While water availability shortages have occurred as expected, total water use actually declined nearly 9 percent between 1980 and 1995, according to USGS. [3] As figure 13 shows, after continual increases in use from 1960 to 1980, total use began declining in 1980.

[1] In its 2002 report to Congress, USGS described the concepts for a national assessment of freshwater availability and use. (*Report to Congress: Concepts for National Assessment of Water Availability and Use*, Circular 1223, 2002.)

[2] Pub. L. No. 89-80, 79 Stat. 244 (1965).

[3] 1995 is the most recent data available; USGS' 2000 national water use information is not yet ready for publication.

Figure 13: Trends in Water Withdrawals by Use Category, 1950-1995



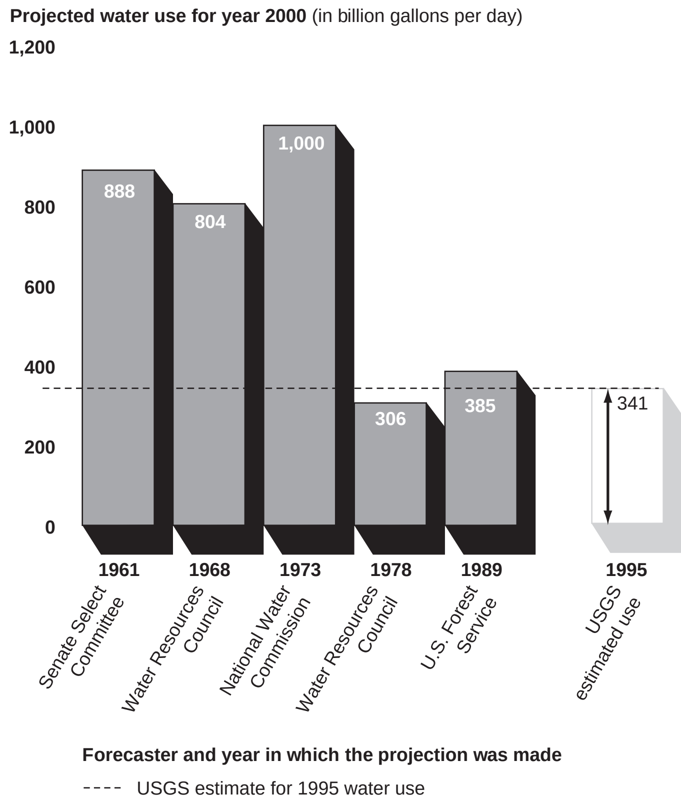
Sources: USGS (chart data and top photo), Natural Resources Conservation Service (photos), and GAO (analysis).

The reasons for the decrease in actual use illustrate why forecasting water use is so difficult. According to USGS, most of the increase from 1950 to 1980 was due to expanded irrigation and hydropower generation. In the 1980s, more efficient irrigation techniques, coupled with new technologies that lowered industrial use, helped ease demand more than anticipated and returned more water to the nation's waterways and aquifers. Water use also declined because of enhanced public awareness and many states' conservation programs. Only public supply and rural use, driven by population growth and livestock needs, respectively, continued to grow after 1980. Accordingly, a 1999 USDA study found that past water use projections for 2000 show consistently large differences among the forecasts and large discrepancies between projected and actual water use (fig. 14).[4] Key factors influencing some of the excessive projections include overestimating population increases, not accounting for technological advances, not anticipating the introduction of environmental laws, and underestimating the impact of conservation efforts.[5]

[4] Brown, Thomas C. 1999. *Past and Future Freshwater Use in the United States: A Technical Document Supporting the 2000 USDA Forest Service RPA Assessment.*

[5] Various agencies, such as the Environmental Protection Agency, have programs that provide technical assistance to states, water districts, and water users for efficiency, conservation, and reuse efforts.

Figure 14: Projections of United States Water Use for 2000



Sources: U.S. Forest Service (data), USGS (data), and GAO (analysis).

The most recent water use—but not availability—forecast is the USDA's 1999 projection for 2040, which identifies a rise in total water use of only 7 percent despite a 41-percent increase in the nation's population. However, the agency includes a warning about the tenuous nature of such projections. For example, irrigated acreage is one of the most important yet uncertain assumptions in the projection. If irrigated acreage does not drop in most Western river basins as assumed, use may be substantially above the estimate. As such, there are compelling reasons for concern regarding the future availability of freshwater to meet the nation's growing demands.

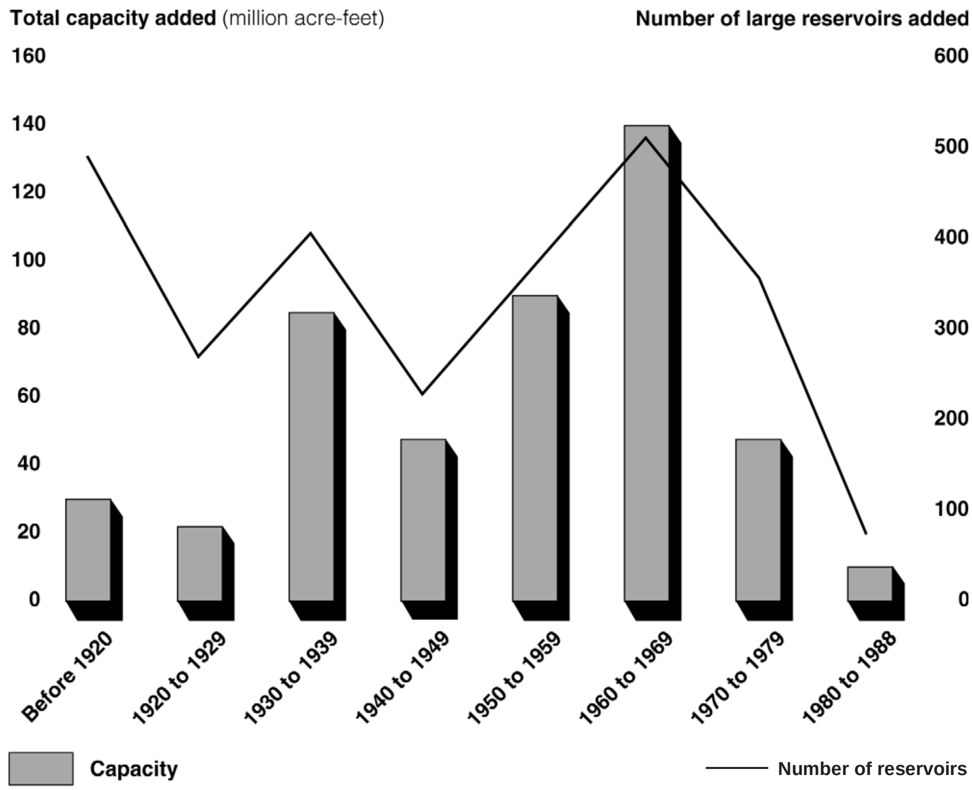
Trends in Water Availability and Use Raise Concerns about the Nation's Ability to Meet Future Needs

While the nation does not have a current assessment of water availability and use, current trends raise concerns about the nation's ability to meet future needs. Numerous signs point to the danger that our freshwater supply is reaching its limits. These indicators include constraints on surface storage capacity and depletion of ground-water resources at the same time as demands for freshwater are on the rise. Increased demand comes from a growing population and pressures to keep water instream for fisheries, wildlife habitat, recreation, and scenic enjoyment. The potential effects of climate change create additional uncertainty about future water availability and use.

Surface Storage Construction and Maintenance Is Declining

The construction of large reservoirs in the United States has slowed markedly since peaking during the 1960s, as shown in figure 15. Reclamation has only one large water storage project underway—Animas-La Plata in Colorado and New Mexico; the Corps has none. Furthermore, because of the high cost and ecological impact of reservoirs and dams, researchers and agency officials generally agree that it is unlikely that the construction of such large-scale projects will be at the forefront in meeting future water needs.

Figure 15: Number and Capacity of Large Reservoirs Completed by Decade



Sources: USGS (data) and GAO (analysis).

Available evidence also indicates that existing reservoirs may not able to continue storing water at current levels. Many of the federal and nonfederal dams that support storage reservoirs are aging and in need of repair. The American Society of Engineers has rated over 2,000 dams as unsafe, and nearly 10,000 as having high hazard potential, according to the Federal Emergency Management Agency's fiscal year 2001-2002 report to Congress on the National Dam Safety Program. According to Reclamation officials, approximately 50 percent of Reclamation's dams were built before 1950, and many of these before the development of current engineering standards. Reclamation recognizes that upgrading and maintaining existing infrastructure is vital to ensuring dependable supplies of water, and anticipates that future costs to rehabilitate Reclamation's infrastructure will be substantial. The Corps estimates it has a critical maintenance backlog of $884 million, largely for dredging waterways and repairing structures such as locks, dams, and breakwaters. While the direct impact on water supply is not clear, extensive maintenance and repair will be needed in future years to ensure the continued viability of the water management infrastructure.

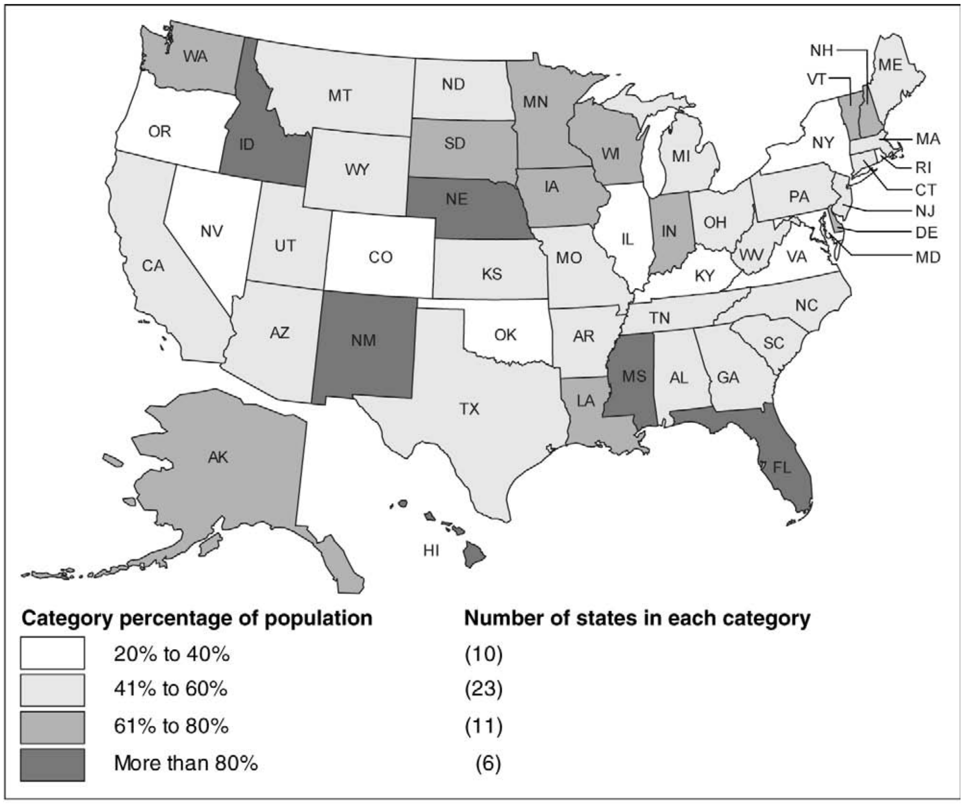
Moreover, the amount of water available for use from these reservoirs is continually being reduced by sedimentation—the flow of soil, rock and other natural materials into reservoirs. Over time, sedimentation can significantly reduce reservoir water storage capacities. According to a 1995 Resources for the Future report,[6] the total reduction resulting from the buildup of sediment is estimated at about 1.5 million acre-feet per year. For example, USGS' reservoir sedimentation studies in Kansas found that decreases in water-storage capacity from sedimentation ranged from less than 5 percent to about 50 percent at various locations.

Ground-Water Is Being Depleted

As shown in figure 16, ground-water is a major source of drinking water in every state. It provides about 40 percent of the nation's public water supply, and more than 40 million people—including 97 percent of the rural population—supply their own drinking water from domestic wells. Ground-water is also the source of about 37 percent of the water used for irrigation and livestock, is a major contributor to flow in many streams and rivers, and has a strong influence on river and wetland habitats for plants and animals.

[6] Resources for the Future, established in 1952, conducts independent research on environmental and natural resource issues.

Figure 16: Estimated Percentage of Population Using Ground-Water as Drinking Water in 1995 by State

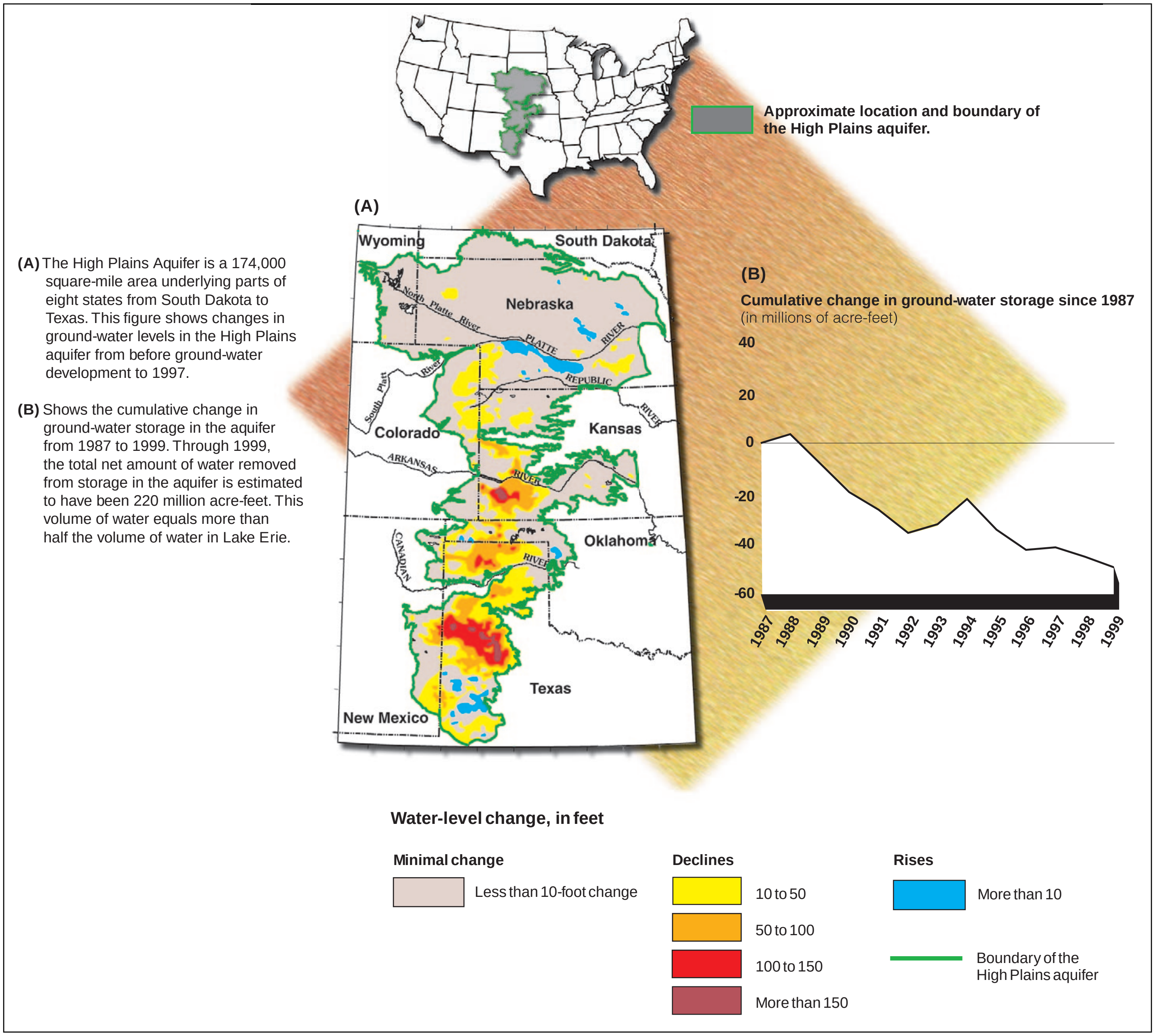


Sources: USGS (data) and GAO (analysis).

Ground-water depletion is occurring across the nation. According to USGS, ground-water depletion may be related to the slowed construction of surface reservoirs in recent years—as surface-water resources become fully developed and allocated, ground-water commonly offers the only available source for new development. USGS has documented significant ground-water depletion in particular areas of the Southwest; the Sparta aquifer of Arkansas, Louisiana, and Mississippi; the Cambrian-Ordovician aquifer of the Chicago-Milwaukee area; and the High Plains aquifer (consisting largely of the Ogallala aquifer). The High Plains aquifer underlies a 174,000-square-mile region including parts of eight states (Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming) and supplies about 30 percent of all ground-water used nationwide for irrigation.

Ongoing water-level monitoring in the High Plains aquifer provides a well-documented example of the long-term depletion of ground-water resources. Ongoing monitoring, initiated in 1988, found that the intense use of ground-water has caused major declines in the water level and reduced the ground-water remaining in storage in some areas to a level that makes the aquifer no longer economical to use. As shown in figure 17, the changes are particularly evident in the central and southern High Plains, where more than half of the ground-water that was available before pumping started has been depleted. Through 1999, an estimated 220 million acre-feet have been removed from storage in the aquifer—or more than half the volume of water in Lake Erie. Water levels continue to decline in many areas of the aquifer, but the rate of decline has slowed during the past 2 decades in some areas. The decline is attributed to decreases in irrigated acreage, improvements in irrigation and cultivation practices, and above-normal precipitation and groundwater recharge during the period.

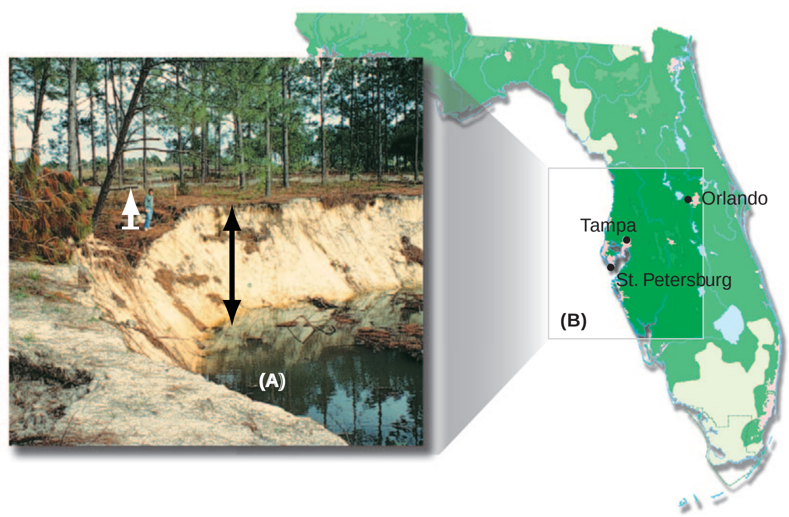
Figure 17: Changes in Ground-Water Levels in the High Plains Aquifer from before Irrigation Pumping to 1999



Sources: USGS (data) and GAO (analysis).

Ground-water depletion has, in some cases, resulted in land subsidence and a permanent reduction of an aquifer's water storage capacity. According to USGS, many areas across the United States have experienced subsidence, a decline in land-surface elevation caused by the removal of subsurface support through the withdrawal of ground-water. Subsidence can severely damage structures such as wells, buildings, and highways, and creates problems in the design and operation of facilities for drainage, flood protection, and water distribution. Furthermore, the compaction of aquifer materials that causes subsidence can result in a permanent reduction of 10 to 30 percent of the storage capacity of some aquifer systems. In the arid Southwest, subsidence shows as deep fissures or "cracks" in the earth's surface, while in the humid East, subsidence is evidenced by "sinkholes." Figure 18 shows a sinkhole in west-central Florida caused by drilling for a new irrigation well.

Figure 18: Sinkhole in West-Central Florida Caused by Development of a New Irrigation Well



Development of a new irrigation well in west-central Florida **(B)** triggered the sinkhole in the photo above **(A)**. A person (near the white arrow) stands next to this sinkhole to give an idea as to its relative size.

Sources: USGS (photo and caption), Map Art (map), and GAO (analysis).